somewhat greater than at Jacksonville. The duration of the storm at Savannah was about 2 hours, and the average velocity during that time was 55 miles per hour.

The storm passed to the westward of Charleston, and though the wind at that station attained a velocity of 62 miles per hour for five minutes, but little damage was done. A velocity of 50 miles per hour prevailed continuously from 1.10 to 2.10 p. m., and an average hourly velocity of 44 miles prevailed from 12.45 to 3.30 p. m. The total fall in pressure amounted to but .4 inch, all of which had been recovered by 7 o'clock p. m.

North of Charleston the storm winds appeared to diminish in strength. There are no Weather Bureau stations directly in the path pursued by the storm between Charleston and Richmond, although it must have passed within 30 or 40 miles of the Weather Bureau station at Raleigh. The wind register at the last-named place showed a maximum velocity of only 26 miles, and the greatest hourly velocity was but 23 miles. At Charlotte, about 120 miles west-southwest, the maximum velocity was also 26 miles. Here a gust preceded the storm proper by about an hour, the wind in the interval being almost calm. The greatest hourly velocity at Charlotte was 20 miles.

A maximum velocity of 34 miles per hour was recorded at Lynchburg, Va., another station on the western side of the storm's path, and the greatest hourly velocity was 26 miles. At Norfolk on the eastern side, and at about the same distance from the storm center, a maximum velocity of 38 miles was registered ten minutes later than the time of maximum velocity at Lynchburg. While the maximum velocity at Norfolk was but slightly greater than at Lynchburg, the velocity of the wind on the average for the six hours ending midnight of the 29th was exactly twice as great as at Lynchburg. No safe conclusion can be drawn from this fact, however, since the ratio of the wind velocity at Lynchburg to that of Norfolk is about as the numbers 4 to 10.

The storm center evidently passed slightly to the westward of Washington. The wind gradually increased in violence, reaching a maximum velocity of 66 miles per hour for five minutes at 11.15 p. m., and maintaining an average velocity of 56 miles from 10.40 p. m. to 11.40 p. m. The wind was remarkable for this locality both on account of its duration and the high velocity attained. The trees in the city and suburbs suffered greatly, although in sheltered places little damage was done. At the Dalecarlia Reservoir (a sheet of water a little less than an eighth of a mile wide) the effect of the increased velocity of the wind, caused by passing over a water surface, is plainly seen. The north bank of the reservoir is lined with a grove of pine trees about 6 inches in diameter. Probably 80 per cent of the trees on the northern edge of the reservoir were broken off 10 to 15 feet above ground, while the destruction at some distance inland from the water was not more than about 5 per cent.

The wind at Baltimore, 40 miles east-northeast of Washington, was less violent than at the last-named place, the maximum velocity for five minutes being but 36 miles per hour.

At Harrisburg, Pa., the winds were even more violent for a short period than at Washington. The maximum velocity of 72 miles per hour occurred at 1.10 a. m., two hours, lacking five minutes, later than at Washington. This would give the storm a rate of progression of over 50 miles per hour, somewhat greater than the average velocity over the entire course.

The greatest average hourly velocity at Harrisburg was 47 miles for one hour and 45 miles for two hours.

Instrumental records of wind velocity between Harrisburg and Lake Ontario are wanting, but from reports of damages by wind at intermediate points it is inferred that there was a decided lull in the violence of the storm while passing through northern Pennsylvania and central New York, followed by a renewal of activity in Cayuga and Cortland counties, New York. It passed thence to the St. Lawrence Valley as an ordinary rain and wind storm.

Comparison of the relative wind velocities on the two sides of the hurricane can not well be made. The number of self-registering wind instruments in the storm's path was quite small, and moreover there is considerable uncertainty regarding the exact position of the area of lowest pressure. Local differences of anemometer exposure also prevent comparison of wind velocities except under the most favorable circumstances. The maximum velocities recorded near the center of the storm as at Jacksonville, Savannah, Washington, and Harrisburg were the highest ever known.

It may also be interesting to note that though the storm passed northward through nearly 15° of latitude its easting was but 3.5°. The general course of West India hurricanes after passing the lower latitudes is northeasterly. In the present case the pressure distribution to the eastward seemed to give the storm a more northerly direction of motion.

NOTES BY THE EDITOR.

FORMS OF CLOUDS.

On several occasions the Editor has stated that there is probably no peculiar form of motion that is possible for a gas that may not be found illustrated in some meteorological phenomenon and many of these forms are visibly illustrated in the ordinary clouds themselves. Numerous students of cloud forms have, during the past two hundred years, described the great cumulus clouds, from whose tops there stream forward a haze which stretches many miles in the approximate direction toward which the thunderstorm is moving. In the early part of the present century the study of these overflows was a favorite topic with Espy, Daniell, Dalton, and other observers. This overflow from the top of the cloud is mechanically similar to the gentler overflow of any current of air on itself when it has risen higher than its position of equilibrium. Similar overflow currents are frequently to be observed in the rivers and the oceans, and there, as well as in the atmosphere, we may observe the phenomena, due to the fact that two currents are flowing in nearly opposite directions while the boundary surface between them becomes mechanically unstable and is, therefore, thrown into a great variety of curves, waves, and breakers. When the horizontal motions of upper and lower layers are strongly opposed to each other and especially when there is a thin stratum of intervening quiet air the median layer is thrown into a movement like that of a series of horizontal rolls which remain stationary if the upper and lower winds are equal, but ordinarily move along slowly in the direction of the stronger current. As they advance their movements sometimes become slower until finally the rotary motion practically ceases and the clouds, having diminished to a very small size, glide smoothly and slowly as if along down a gently inclined plane. If the descent is rapid, the clouds dwindle away and disappear more rapidly, but if it is very slow, they may extend for a hundred miles as a sheet of the most delicate cirrus or cirro-cumulus, or if they are lower down, alto-cumulus. Sometimes we lose sight of the origin of the descending layer of air and the observer recognizes only a lower quiet mass of air above which another is rapidly gliding.

Whenever an obstacle interferes with the movement of the air it is thrown into a series of disturbances which may either be a gentle rise and overflow or of the nature of horizontal rolls or of the simpler structure represented by the standing waves behind an obstacle in the current of a river. In the latter case the wave formation is oftentimes invisible, but sometimes the air is thrown up high enough, and cools by expansion low enough, to form a cloud at the summits of the successive waves. In most cases such formations are attended with a mixture of the upper and lower layers of air within each whirl or wave; if in such cases the air that is drawn in has an abundance of moisture, a cloud is formed which, however, diminishes as it proceeds further to the leeward, owing to the steadily increasing proportion of drier air and the absorption of heat radiated from sun or earth. In other cases the general equilibrium of the atmosphere is so near to the condition of unstable equilibrium that a cloud which is small when first formed at the location of the first wave becomes larger as it advances to the leeward and, finally, breaks up into a mass of small rolls and clouds that constitute a continuous horizontal layer of stratus clouds and, finally, miles away, develops rain. The careful observer will find abundant illustrations of these processes, and that, too, as frequently in the torrid zone and tropics as in the temperate zone and polar regions. Among the special contributions in this number of the REVIEW Mr. Proctor describes the horizontal rolls seen by him among the high lands of western North Carolina. In his Preparatory Studies, and still more fully in the American Meteorological Journal, Vol. VIII, pp. 250–264, the Editor has given details of many forms of "overflow clouds," and in a memoir on the classification and nomenclature of clouds he has given these their proper place. To the weather forecaster they are exceedingly useful as indications of approaching storm.

The following note by Mr. John Aitken, dated March 28, 1896, and published in the Proceedings of the Royal Society of Edinburg, is here inserted as showing still another view of the same subject:

There are two points connected with clouds on which I wish to make a few remarks. The first is on the classification of clouds, and the second on the manner in which certain forms of clouds are produced. It may be as well to remark at the outset that the observations are those of an "outsider," being in a department of meteorology to which the writer has given but little attention, and they have been written with the view of calling attention of specialists and getting their opinion of the subject.

It appears to me that in classifying clouds they ought, first of all, to be divided into two great classes. In the one class should be placed all the clouds in the process of *formation*, and in the other those in the process of *decay*. The two classes might be called—*clouds in formation* and *clouds in decay*. We may take cumulus clouds as an example of the former and nimbus of the latter. My observations made in the clouds themselves have shown that there is a difference in the structure of these two classes of clouds. In clouds in formation the water particles are much smaller and far more numerous than in clouds in decay, and while the particles in clouds in decay are large enough to be seen with the unaided eye when they fall on a properly lighted micrometer, they are so small in clouds in formation that, if the condensation is taking place rapidly, the particles can not be seen without the aid of a lens of considerable magnifying power. In the former case the number of particles falling per square millimeter is small, while in the latter they are so numerous that it is impossible to count them.

It appears that one good end might be served by adopting this classification. It would direct the attention of observers more to looking on the processes going on *in decay* for an explanation of many of the forms observed in clouds. In most books on clouds, when describing the different shapes of clouds, it is almost always assumed that they are in the process of *formation*, and the whole explanation of the shapes taken by the clouds is founded on this supposition. Now it is very evident that very many clouds are in the process of decay, and their forms can only be explained by the processes going on under these conditions.

This brings me to the second point in this communication, namely the manner in which ripple-marked cirrus clouds are produced. The explanation which has generally been accepted of the formation of this form of cloud is that the ripple marking are due to the general movements of the air giving rise to a series of eddies the axes of the eddies being horizontal, and roughly parallel to each other. It is very evident that the air revolving round these horizontal axes, that is, in a vertical plane, will at the lower part of its path be subjected to compression, and at the upper part to expansion. The result of this will evidently be, supposing the air to be nearly saturated with moisture, a tendency for cloudy condensation to take place in the air at the upper part of its path, and it is this cloudy condensation in the upper part of the eddies that is supposed to produce the ripple-like cirrus; each ripple mark indicating the upper part of an eddy. One objection I have always held to this explanation is, that it is difficult to imagine that the small amount of elevation and consequent expansion and cooling could give rise to so dense an amount of clouding as is generally observed. Any clouding produced in this way one would expect to be extremely thin and filmy. I have for the last few years made frequent observations of these clouds, and I have to admit that I have never once seen them in the process of formation, or seen one appear in a clear sky. In all cases that have come under my observation, these ripple clouds have been clouds in decay. They are generally formed out of some strato-cirrus or similar cloud. When we observe these strato-cirrus in fine weather, it will be found that they frequently change to ripple-marked cirrus before vanishing. The process of their formation would seem to be: The strato-cirrus gradually thins away till it attains such a depth, that if there are any eddies at their level, the eddies break the stratus cloud up into parallel or nearly parallel masses, the clear air being drawn in between the eddies. It will be observed that this explanation requires the eddies, but not to produce the clouding, only to explain the breaking up of the uniform cirrus cloud into ripple cirrus.

One thing which supports this explanation is that lenticular-cirrus are frequently observed with ripple markings on one or more sides of them just where the cloud is thin enough to be broken through by the eddies. If we watch these lenticular formed clouds under these conditions, we frequently see the ripple markings getting nearer and nearer the center as the cloud decays; and at last, when nearly dissolved, the ripple marking will be seen extending quite across the cloud. It seems probable that "mackerel" and other cloud forms may be produced in the same way.

The shapes which these cirrus assume are much more varied than is generally supposed. I lately observed a most interesting form in the south of France while the mistral was blowing strongly. There were a few cirrus in the sky at the time, and one of these was rapidly being broken up into irregular ripple forms, but at one point there was formed a most perfectly cylindrical-shaped piece, its length being about twenty times its diameter. The whirling effect of the eddy was very evident by the circular streaking of the clouding. Further, this cloud was evidently hollow, that is, the interior was filled with clear air, as the cloud was thinest along the axis, and it had all the appearance of a revolving tube of cloudy air.

It is not contended here that ripple clouds are never produced in the manner which has generally been accepted, only that so far as the writer's observations go they have never been observed forming in the manner supposed. It is hoped that others will put the explanation here offered to the test of observation, and it is principally with a view of getting others to repeat the observations that this has been written.

These conclusions as to the formation of cirri by the decay of stratus harmonize perfectly with the observations and publications of the Editor, and he hopes soon to print in the MONTHLY WEATHER REVIEW the above mentioned memoir on the subject of clouds and their nomenclature, as read at the Springfield meeting of the A. A. A. S. in August, 1895. Meanwhile the following thoughts may be suggestive to those who are studying the local clouds in connection with the Daily Weather Map. The denser air that is near the ground on the northwest and west sides of a symmetrical circular area of low pressure pushes under the warmer, lighter air on the southeast and south sides; the latter is banked up and pushed eastward, and being lifted up overflows, mostly toward the east, but a little toward the west. The heavy rains on the south and east sides of the low locate the region where the uplifted air is piled up highest and forms the thickest cloud layer; immediately below these rain clouds the wind is still from the southeast and south, but the clouds themselves are flowing from some point between the south and west. This cloud layer from the southwest is flowing over a lower wind from the south or east, or even northeast, and, therefore, the interference of these currents at the intermediate surface breaks up the lower surface, or perhaps even the whole of the horizontal wedge of descending stratus, into rolls (or cumulo-stratus stretching horizontally in imitation of rolls) whose axes stretch from some northerly point to the opposite southerly point; the exact trend depends upon the relative strength of the upper and lower current. If the lower is the stronger, the trend will be southeast rather than southwest, and as stronger winds are nearer the lowest pressure, therefore the trend will vary with the distance from the center of low pressure around which these winds and clouds are circulating. If this center is near at hand and bears northwest from the observer, and if it is moving eastward, and especially if the observer's wind is south and the lower cloud motion from the southwest while the trend of these cloud rolls, or the perspective vanishing point of the parallel striæ on the lower surface of the sheet of stratus above the observer be east and west, then the region of heavy cloud and rain will probably not move or extend southward to his station, but passing eastward, will probably keep to the north of him. If the barometric depression is a long trough, these relations are modified and the rain may reach him. If the trend of the axes of the rolls is from southwest to northeast and is then soon observed to change so as to become northwest and southeast, this indicates that the clearing region is rapidly approaching with its cooler air and that there is less prospect of rain.

But as these phenomena are affected by the topography of of the surrounding country, therefore such rules for Washington may not apply strictly to another locality, and the Editor will be pleased to publish such rules as others may have deduced.

HOAR FROST ESPECIALLY RICH IN NITROGEN.

(Translated from A. LANCASTER in Ciel et Terre, XVII, p. 54.)

Messrs. Petermann and Graftiau in a memoir, published by the Academy of Sciences of Belgium, and entitled Researches on the Composition of the Atmosphere, demonstrate the special richness of hoar frost in nitrogenous compounds, and draw attention to the important part that hoar frost plays in adding to the stock of nitrogenous matters in the forest, as well as to the purifying influence that the forests exercise on atmospheric air.

The truly remarkable richness of hoar frost merits attention as one of the interesting points in the complicated mechanism of the circulation and distribution of nitrogen throughout the world. The frost work which is attached to the branches of trees presents to the air, which surrounds it and is continually renewed, a large surface for the absorption of all the soluble bodies that it carries, and the isolated trees, the plantations, and the forests act like immense filters purifying the air that circulates through their foliage, robbing it of those nitrogenous combinations which, being returned to the soil by a thaw, serve again as nutriment to the plants and thus reenter the vital cycle. When one sees the branches of the trees bending under the weight of the frost, when the latter accumulates to the point of breaking the larger branches, we should recognize that this represents an appreciable factor in the stock of nitrogenous material accumulated in the forests.

The following analyses of one liter of melted frost collected at Gembloux, Belgium, are given in the above work:

	Milligrams of nitrogen.
March 1, 1889	5.86
January 2, 1890	7.70
December 31, 1890	9.00
December 31, 1890	8.00
December 31, 1890	7.02
Average	7.52

During the severe cold of the winter 1894–95, M. Graftiau made some further measurements for the purpose of also taking account of the quantity of frost actually attached to the branches. On February 7, between 9 and 10 a. m., and at a temperature of 16° C. below zero (plus 3.2° F.) he collected the frost attached to different species of trees growing in the arboretum of the agricultural institution at Gembloux. The branches that were heavily ladened with frost were gently detached and then shaken over a sheet of paper. The frost was then collected in a dish and weighed. In this way we could only obtain a part of the frost, therefore, the figures cited below are the minima. The quantities obtained were as follows:

Species.	Weight of—		Surface of branch.
	Frost.	Branches.	
	Grams.	*Grams.*	*Sq. cm.*
Cornus sanguinea	2.0	2.0	30
Populus alba	2.8	3.6	36
Ribes saxatile	5.5	2.5	100
Salix alba	34.1	15.0	203
Salix vitellina	39.3	32.1	270

Graftiau also weighed the frost on an entire shrub (*betula rotundifolia*). The cube limited by the extremities of the branches was about 1.5 meters on a side; the weight of the frost was 1.755 kilograms. The melted frost was analyzed and each liter contained: 4.0 milligrams of nitrogen as ammonia and 1.2 milligrams of nitrogen as nitrates and nitrites, or a total of 5.2 milligrams of combined nitrogen.

This frost of February 7 was not at all remarkable, and yet we see that its weight exceeded 1 kilogram for each cubic meter of space occupied by the branches. In mature forests the branches occupy, at a low estimate, a space of about 100,000 cubic meters to the hectare, and can, therefore, collect 100,000 kilograms of frost which represent, approximately, half a kilogram of combined nitrogen, if we adopt as the base of our calculation the small amount of frost that collected on the branches during the severe frost of February 7. If, for an average, we take 7.5 miligrams instead of 5, the deposit would be nearly 800 grams of nitrogen to the hectare, or 7 pounds to the acre.

Frost is sometimes formed to an extraordinary amount. It is then capable of breaking by its own weight branches that are 10 centimeters in diameter, which happened some years ago in different parts of the country. Therefore, the quantity of nitrogen that is given to the soil by the frost that falls on it is very considerable.

These authors, therefore, have with good reason said that the frost represents an appreciable factor in the reserve of nitrogen within forest areas. If we add to this the nitrogen contained in the rain, the dew, and the fog, we can easily explain why, without any artificial addition of nitrogen and without the intervention of those plants that serve to fix atmospheric nitrogen, the forest vegetation is always well supplied with nitrogen, and it also shows how the soil of forest areas grows richer in this element which is given to it by the detritus, or the waste of the forest.

[May we not also suggest that the stunted foliage on the summits of mountains, fed as it is by the melting of frost and snow, may be peculiarly well supplied with nitrogen.—C. A.]

ATMOSPHERIC REFRACTIONS AT THE SURFACE OF WATER.

In response to an inquiry about mirage, the Editor has collected the following notes from recent publications:

Prof. Charles Dufour of Lausanne communicated to the Academy of Sciences at Paris a memoir, of which Mr. Lancaster (*Ciel et Terre*, April, 1896, Vol. XVII, p. 88) gives the following summary—

Abnormal refractions are often observed on Lake Leman [*i. e.*, Lake Geneva, Switzerland]. If the air is colder than the surface water we have conditions favorable for mirage; the path of the curved